Spacecraft Communications Payload (SCP) for Swampworks

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LONG-TERM GOALS

The long-term goal of the Spacecraft Communications Payload (SCP) program is to build a payload that can be flown on a constellation of low earth orbiting satellites. The immediate goal of the SCP program is to design, build, and fly an SCP on the TacSat-3 spacecraft. This payload will serve as a router in the sky for the Ocean Data Telemetry Microsatellite Link (ODTML) system for data exfiltration from ocean buoys.

OBJECTIVES

The objective of this program is to design and build a low cost, low power, space based, two-way communications payload for the TacSat-3 spacecraft. This payload is a protoflight version of the Spacecraft Communications Payload (SCP) concept originally envisioned in ONR SBIR N02-062, Ocean Data Telemetry Microsatellite Link (ODTML) (see Figure 1), and uses a Commercial Off-The-Shelf (COTS) radio frequency (RF) transceiver and modem.

This payload provides data exfiltration/infiltration capabilities via the Internet for ocean buoys and other low data rate sensors, and could also be used to collect data from terrestrial sensors, such as unattended ground sensors (UGSs) and Low Probability of Intercept (LPI) communication devices. In fact, once a system is in place, it could be used for data exfiltration from a host of different data terminals. The intended result of this program is both a near term payload for TacSat-3 and a flight qualified design for future flight opportunities.

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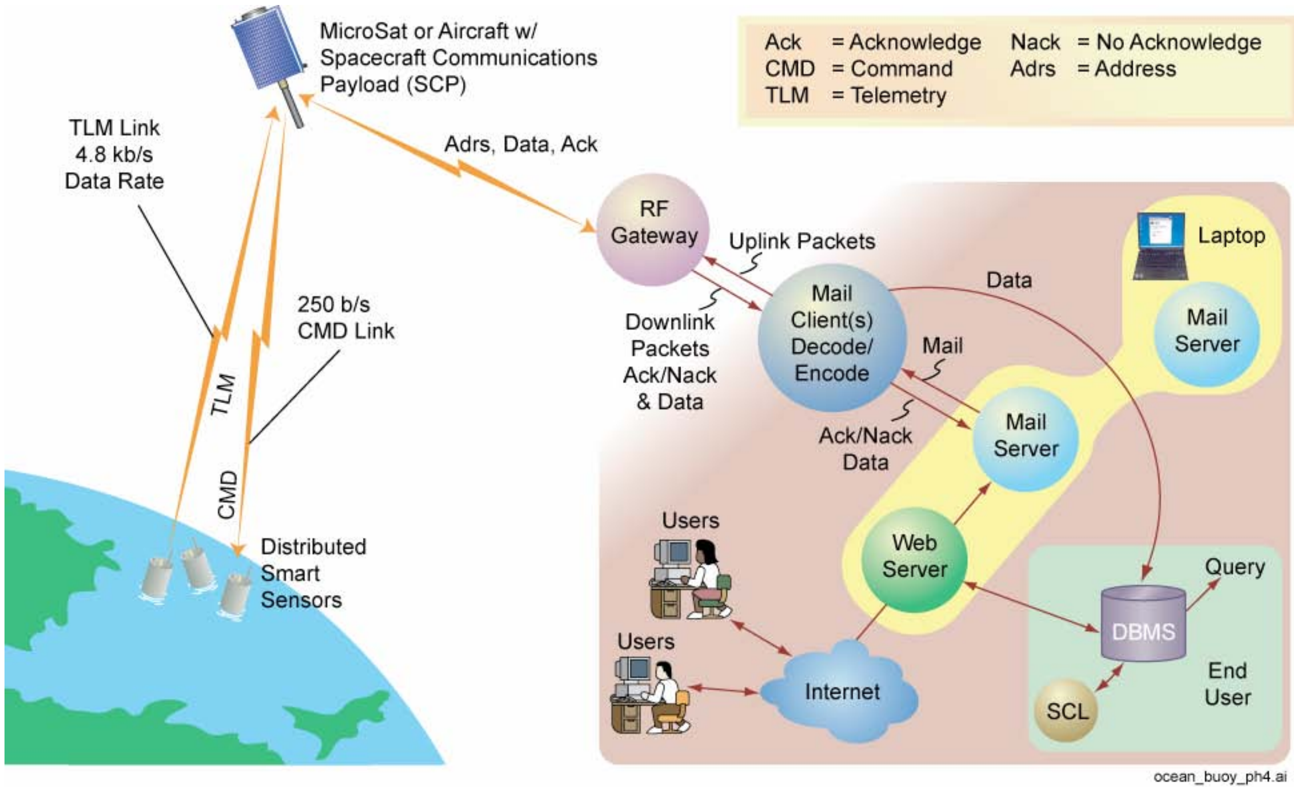

Figure 1. Ocean Data Telemetry MicroSat Link (ODTML) System Architecture

APPROACH

The SCP development team consisted of Praxis and its technical development partners Silver Engineering, Inc. (SEI) and SpaceQuest, Ltd. Praxis was primarily responsible for project management, systems engineering, structural/thermal/mechanical engineering, and integration support. SEI was primarily responsible for electronics and software development. SpaceQuest was responsible for the RF hardware and modem. While each company had a clear definition of roles and tasks in the project, the three companies employed an integrated product development approach that fully utilized concurrent engineering to reduce schedule and technical risks.

Our approach in designing and building the SCP has been to use COTS parts that have proven their capabilities in microsatellites, and to borrow from the information technology sector as much as possible. This new approach has resulted in a low cost, small size payload that will perform a militarily relevant mission.

WORK COMPLETED

(1) Defined the requirements for the SCP to ensure that it will be flexible and robust enough to meet all objectives.

(2) Obtained agreement from the TacSat-3 management on the interfaces between the SCP and TacSat-3.

(3) Created a space qualified mechanical design ready for flight.

(4) Performed necessary testing to ensure that the SCP will perform its functions on orbit.

(5) Created an environmental test plan for the SCP and the antenna.

(6) Designed, built and tested the SCP Processor (SCPP) Board.

(7) Created the SCP communication protocol to provide a simplified method of addressing multiple buoys using the SCP as a "master."

RESULTS

We have built a multi-frequency RF SCP for the TacSat-3 spacecraft. Our overall objective is to enhance the U.S. Navy's ocean-monitoring capabilities by providing a network of communications relays that will enable the users to send commands to and receive telemetry from autonomous ocean platforms on a near real-time basis.

The following performance specifications were the minimum requirements for the SCP and were met by our design:

- Able to transmit greater than 50,000 bits of data per day per buoy
- Expend less than 0.1 joule per bit
- Capable of global access
- Capable of determining the position of buoys

The SCP has been designed to interface with and fly on any of the following flight opportunities:

- As an integrated payload on a free-flyer microsatellite, such as TacSat-3
- As a piggyback payload on any LEO satellite
- As an unpressurized payload aboard the International Space Station (good for long-term observation of seasonal, oceanic effects)
- As a Space Shuttle payload (although the one- to two-week in-flight duration is short, many of the experiment objectives can still be achieved)
- On an airborne platform, manned or unmanned

Pictures of the five major payload components designed and built for this program, and the complete SCP, are shown in Figure 2.

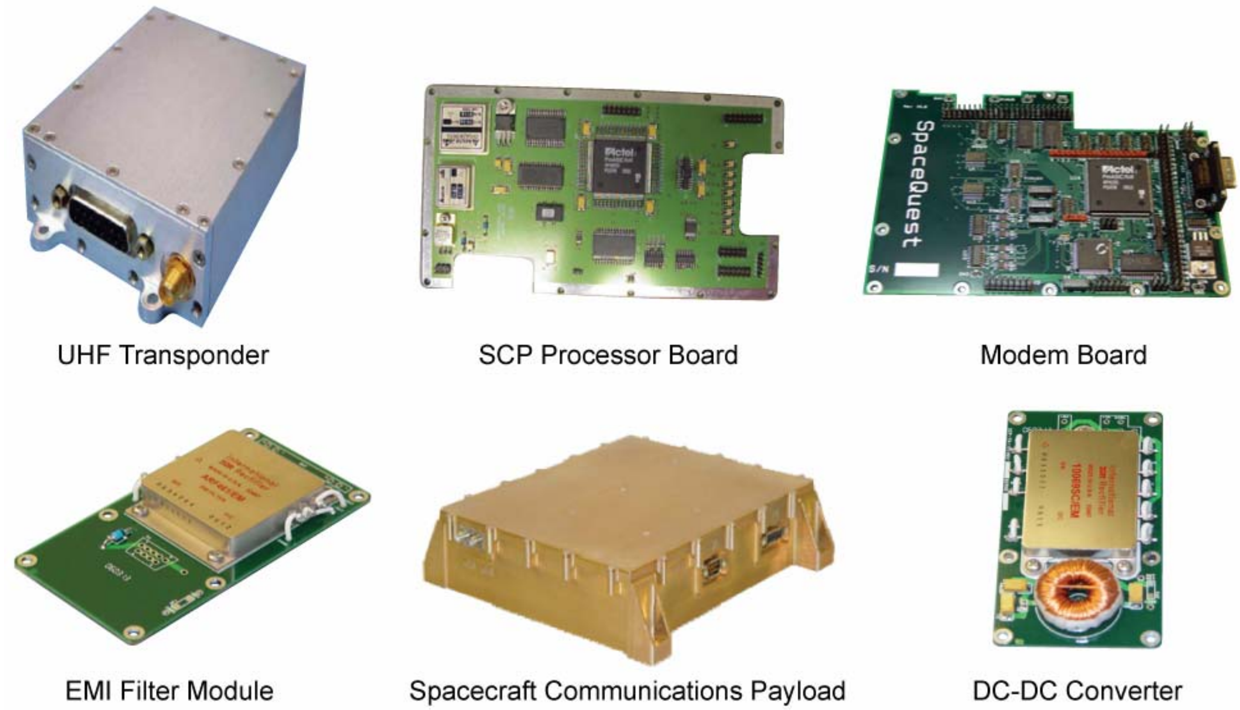

Figure 2. Major payload components designed and built under contract N00014-05-C-0117

IMPACT/APPLICATIONS

This payload is the first step toward the deployment of a constellation of cost effective, space qualified Communication Relay Payloads to meet the DoD (and civil sector) needs for a real-time Integrated Ocean Observing System. The U.S. Navy will be the direct beneficiary of the system, as it will enhance the Navy’s ability to gather sensor information on a global and near real-time basis by interrogating and tasking ocean observing platforms. Such capability has applications in the area of ASW, surveillance, and other ocean-monitoring activities. An ancillary benefit would be the ability to also monitor other data sensors, such as unattended ground sensors and Low Probability of Intercept (LPI) communication devices. In fact, once a system is in place, it could be used for data exfiltration from a host of different data terminals.

The ability to provide near real-time situational awareness is essential for the next generation ocean observing system because the response time to an occurring event, military or scientific, is increasingly tied to operational effectiveness. The ability to query or interrogate a sensor that has detected an event is important because users often desire confirmation or more frequent observation of the event. Current systems do not meet these needs because they are based on dated technologies.

A major achievement of this program will be the increased intelligence value realized by being able to network a group of individual sensors into a grid of smart, cooperative nodes. With on board processing, smart sensor nodes will evaluate gathered data and make knowledge-based decisions on whether to notify other sensors or query them on their information. In other words, they will become a team, sharing data and helping each other to know either what has happened or what to expect. Data fusion, data sharing, and data queuing are all new capabilities that will be introduced by this concept of networking smart sensors. This will greatly enhance the intelligence value of the sensor grid over having individual sensors unable to communicate.

RELATED PROJECTS

Ocean Data Telemetry Microsatellite Link (ODTML). The ODTML system is a two-way low-rate data communication system supporting small disadvantaged scientific and environmental buoys on a global basis. Communications to and from Smart Sensor Nodes (SSNs) aboard the buoys to ODTML Portable Gateway Stations (PGSs) will be accomplished via a constellation of Spacecraft Communications Payloads (SCPs) hosted aboard low Earth orbit (LEO) satellites. The PGSs may be connected to the Internet, private Local Area Networks (LANs), or dial-up circuits.

Smart Sensor Node (SSN) In House (Praxis) R&D Effort. To evolve to this “smart” sensor goal, Praxis undertook an in-house effort to design a small, low cost RF terminal with a CPU and a DSP to increase the processing capability of terminals to allow on-board data fusion. These SSNs are now more than just dumb data terminals, and being able to process and share data allows them to react to detected data and queue other buoys based on the detected event, greatly enhancing their overall effectiveness.

Integrated Sonobuoy Advanced Networking (ISAN), NAVAIR SBIR N03-189. This SBIR’s objective was to develop a system design and feasibility concept for an integrated ocean data collection system. Central to this design was the SCP acting as a “router in the sky” communicating with smart sensor nodes. Praxis defined requirements for a SCP that could fly on either an aircraft or a spacecraft.

TacSat Program. The Office of Force Transformation (OFT) started the TacSat program in 2003, and has passed its program management on to AFRL. This program is looking for fast turnaround, low cost payloads to fly to demonstrate that space doesn’t have to “cost too much and take too long.” NRL built TacSat-1 and AFRL is building TacSat-2 and TacSat-3. TacSat-2 is nearing completion and TacSat-3 is in the planning stage with a projected launch date of 17 October 2007. Our schedule for the SCP will allow us to meet that date.

OFT Standard Bus Program. OFT has funded AFRL and NRL to come up with a generic bus design to be used for TacSat-4 and beyond. The SCP is likely to be manifested on future TacSats because of its small size and low cost.

DoD Space Test Program. This is a DoD program that funds I&T costs for payloads to fly in space. Each year a competition is held and payloads are evaluated, and an attempt is made to match payloads with available space rides. ODTML was ranked in the 2004 SERB, and the SCP is built and manifested on TacSat-3. STP will furnish the money to integrate it onto the TacSat-3 spacecraft.